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A Comparative Study of Underwater Image Enhancement Techniques

Dr. D.Deepa[1]
Professor/ Dept. of IT
Bannari Amman Institute of Technology
Sathyamangalam – India

V.L.Sangameshwari[2]
PG-scholar/Dept.of IT
Bannari Amman Institute of Technology
Sathyamangalam – India

Abstract: The quality of underwater images is poor because of specific propagation properties of light in water. So, underwater image enhancement is necessary to increase visual quality. Image enhancement can be done in two domains. Spatial domain and frequency domain. Various approaches like contrast stretching, adaptive histogram equalization, EMD (Empirical Mode Decomposition), UCM techniques are used to enhances the underwater images. Some filtering techniques are also used to avoid the noise in the sea image.

Keywords: spatial domain, frequency domain, image enhancement approach, filters.

I. INTRODUCTION

In recent years, there is a strong interest in knowing what lies in underwater, to monitor marine species, Underwater mountains & plants, to achieve this purpose it is absolutely necessary to use the clear images. Here also discussed the effects of color in underwater images. With respect to light reflection, Church [1] describes that the reflection of the light varies greatly depending on the structure of the sea. Another concern is related to the water that bends the light either to make crinkle patterns or to diffuse. The reflected amount of light is partly polarized horizontally and partly enters the water vertically. An important quality of the vertical polarization is that it makes the object less shining and helps to capture deep colors which may not be possible to capture.

Therefore, when light rays moves from the air to the water, it is partly reflected reverse and at the same time partly enters the water[2].As a result, the underwater images are getting darker and darker as the deepness increases. Not only the quantity of light rays is condensed when it goes deeper but also colors drop off one by one depending on the wavelength of the colors. Red color disappears first at the depth of 3m.Orange color starts disappearing secondly while we go further. Then yellow colour starts disappears at the depth of 10m and the green and purple disappears finally[3].

A certain amount of incoming light is reflected away when it reaches the ocean surface, depending upon the state of the water itself. If it is calm and smooth, less light will be reflected. If it is turbulent, with many waves, more light will be reflected[5].The light that penetrates the surface is refracted due to the fact that light travels faster in air than in water. Once it is within the water, light may be scattered or absorbed by solid particles. Most of the visible light spectrum is absorbed within 10 meters (33 feet) of the water's surface, and almost none penetrates below 150 meters (490 feet) of water depth, even when the water is very clear.

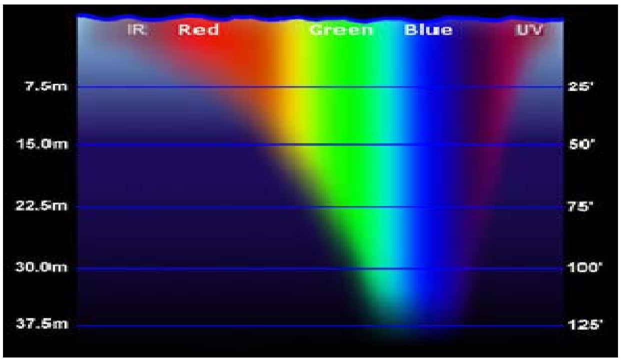

Fig 1- Color penetration pattern

From the fig1 it can be clearly understand that, the blue color travels the longest in the water and in depth due to its shortest visible wave length. Which makes the underwater images having been dominated only by blue color because of this effect of blue color the original color of any object under the water is affected. In addition to excessive amount of blue color, the blur images contain little brightness, little contrast and so on. Spatial filtering term is the filtering operations that are performed directly on the pixels of an image.The process consists simply of moving the filter mask from point to point in an image.Inverse Fourier transform of spectrum is found to get the enhanced image in which pixel values will be modified. Digital image is a 2D discrete light intensity function in which each element is referred as pixel. Let f(x,y) be an original image where f is gray level value of the pixel at spatial coordinates (x,y) and g(x,y) be its enhanced image.The values of pixels in images f and g are denoted by r ands respectively. The relation between r and s is

$$S=T(r)$$

Where T is used to map a pixel value r into pixel value s. Consider a gray scale range [0,L-1] where L= 2k , k be the number of bits used for a pixel in image. Generally 256 gray levels are sufficient for recognizing most natural objects. A 8 bit digital image shown in Fig.1 can take pixel values in the range [0, 255] in which 0 represents black, 255 white and all intermediate values represent different shades of gray. Normalized gray scale range is [0.0, 1.0].

II. Literature Survey

In 2010 Iqbal, K.; Odetayo, M.; James, A.; Salam, R.A.; Talib, A.Z.H. [4] worked on "Enhancing the low quality images using Unsupervised Colour Correction Method,", The affected underwater images reduced contrast and non-uniform color cast because of the absorption and scattering of light rays in the marine environment. For that they proposed an Unsupervised Colour Correction Method (UCM) for underwater image quality enhancement. UCM is based on color matching, contrast improvement of RGB color model and contrast improvement of HSI color model. Firstly, the color cast is concentrated by equalizing the color values. Secondly, an improvement to a contrast alteration method is useful to increase the Red color by stretching red color histogram towards the utmost; similarly the Blue color is concentrated by stretching the blue histogram to the minimum. Thirdly, the Saturation and Intensity parts of the HSI color model have been useful for contrast correction to enlarge the true color using Saturation and to address the illumination problem through Intensity

In 2011 Jinbo Chen; Zhenbang Gong; Hengyu Li; Shaorong Xie, [5] proposed "A detection method based on sonar image for underwater pipeline tracker,". The surveillance and inspection of underwater pipelines are carried out by operators who drive a remotely operated underwater vehicle (ROV) with camera mounted on it. Though in extremely turbid water, the camera cannot capture any scene, even with supplementary high-intensity light. In this case the optical detection devices are unable to complete the surveillance task in recent years; forward looking sonar is broadly applied to the underwater examination, which is not subject to the control of light and turbidity. So it is appropriate for the inspection of pipelines. But the active change of ROV by the water flow will show the way to the aim to escape from the sonar image effortlessly. In adding up, the sonar image is with high noise and little contrast. It is difficult for the operator to identify the pipeline from the images. Furthermore, the observation of underwater pipelines is deadly and time unbearable and it is easy to create mistakes due to the exhaustion and interruption of the operator. Then, the study focuses on rising image processing algorithms to distinguish the pipeline repeatedly. By means of the proposed image processing technique, firstly the images are improved using the Gabor filter. And then these images are useful for an edge detector. Lastly the parameters of the pipeline are designed by Hough transform. To decrease the search area, the Kalman filter is explored to forecast the parameters of the pipeline on the next picture. And the research is shown the vision system is on hand to the observation of underwater pipelines.

In 2011 Laurence likforman –sulem et al proposed a method for enhancement of historial printed document images by combining total variation regularization and non-local means filtering with total variation framework and cleaning image as step and consists of a filter based on Non-local means.

Xiangzhi Bai et al presented a algorithm for infrared IE through contrst enhancement by using multiscale new top-hat transform.In this the overall algorithm is divided into three phases, firstly, multiscale new top-hat transform are constructed to extract multiscale light and dark image regions; secondly, the final light and dark image regions are obtained from the extracted multiscale light and dark image regions and finally,infrared image is enhanced through enlarging the contrast between the final light and dark image regions.

In 2012 Chiang, J.Y.; Ying-Ching Chen, [6] researched on "Underwater Image Enhancement by Wavelength Compensation and Dehazing,". Where light scattering and color modify are two main sources of alteration for underwater shooting. Light scattering is affected by light event on objects reflected and deflected many times by particles present in the water prior to reaching the camera. This in turn lowers the visibility and contrast of the image captured. Color change corresponds to the unstable degrees of reduction encountered by light traveling in the water with diverse wavelengths, depiction ambient underwater environments conquered by a bluish quality. No obtainable underwater processing techniques can handle light dispersion and color change distortions caused by underwater images, and the probable presence of false lighting concurrently. This literature proposed a novel systematic come up to to improve underwater images by a de-hazing algorithm, to give back the attenuation difference along the broadcast path, and to take the pressure of the possible presence of an false light source into consideration.By managing the effect of artificial light, the haze occurrence and inconsistency in wavelength attenuation along the underwater broadcast path to camera are corrected. Secondly, the water deepness in the image scene is predictable according to the remaining energy ratios of diverse color channels obtainable in the background light.

Sharif M. A. Bhuiyan, Jesmin F. Khan CBEMD(Colour based Empirical Mode Decomposition) algorithm is applied to decompose several real color images[10]. FABEMD method is utilized, which employs order statistics filters (OSFs) to get the upper and lower envelopes instead of surface interpolation. EMD is an adaptive decomposition any complicated signal or image can be decomposed into its Intrinsic Mode Functions (IMF). EMD is an analysis method that in many aspects gives a better understanding of the physics behind the signals. Because of its ability to describe short time changes in frequencies that can not be resolved by Fourier spectral analysis it can be used for nonlinear and non-stationary time series analysis[9].

Sharif M. A. Bhuiyan, Jesmin F. Khan CBEMD(Colour based Empirical Mode Decomposition) algorithm is applied to decompose several real color images[10]. FABEMD method is utilized, which employs order statistics filters (OSFs) to get the upper and lower envelopes instead of surface interpolation.

In 2012 bt. Shamsuddin, N.; bt. Wan Ahmad, W.F.; Baharudin, B.B.; Kushairi, M.; Rajuddin, M.; bt. Mohd, F.,[7] developed a technique on "Significance level of image enhancement techniques for underwater images,". Underwater imaging is fairly a demanding in the area of photography specially for low resolution and normal digital camera. There are some problems arise in underwater images such as partial range visibility, low contrast, non identical lighting, blurring, intense artifacts, color diminish and noise. This research concentrated on color diminished. Major application of typical computer vision techniques to marine imaging is mandatory in dealing with the thought problems. Both automatic and manual level methods are used to record the mean values of the stretched histogram.

In 2013 Hitam, M.S.; Yussof, W.N.J.H.W.; Awalludin, E.A.; Bachok, Z., [8] has been worked on "Mixture contrast limited adaptive histogram equalization for underwater image enhancement,". By improving the quality of an underwater image has received substantial attention due to rundown visibility of the image which is caused by physical properties of the water. Here they presented a new technique called hybrid Contrast Limited Adaptive Histogram Equalization (CLAHE) color spaces that specifically developed for underwater image improvement. The technique operates CLAHE on RGB and HSV color spaces and both results are joint together using Euclidean rule. Tentative results show that the future approach considerably improves the visual quality of underwater images by enhancing contrast, as well as dropping noise and artifacts.

III. FILTERS

A. Homomorphic Filtering

Homomorphic filtering is a generalized technique for signal and image processing, involving a nonlinear mapping to a different domain in which linear filter techniques are applied, followed by mapping back to the original domain. Homomorphic filter is used for image enhancement it normally increase the brightness across an image and to remove multiple noises.To make the illumination of an image more even, the high-frequency components are increased and low-frequency components are decreased, because the high-frequency components are assumed to represent mostly the reflectance in the scene. High-pass filtering is used to suppress low frequencies and amplify high frequencies, in the log-intensity domain.

FIG 2: Homomorphic filtering

B. Spatial Filter

A spatial filter is an image operation where each pixel value I(u, v) is changed by a function of the intensities of pixels in a neighborhood of (u, v).In spatial filtering, a lens is used to focus the beam. Because of diffraction, a beam that is not a perfect plane wave will not focus to a single spot, but rather will produce a pattern of light and dark regions in the focal plane. It reduces the noises in the images and increases the contrast. A spatial filter is an optical device which uses the principles of Fourier optics to alter the structure of a beam of coherentlight or other electromagnetic radiation. Spatial filtering is commonly used to "clean up" the output of lasers, removing aberrations in the beam due to imperfect, dirty, or damaged optics, or due to variations in the laser gain medium itself. This can be used to produce a laser beam containing only a single transverse mode of the laser's optical resonator.

FIG 3: Spatial Filter

C. Photographic Unsharp Masking:

In Unsharp masking technique are used to create a mask of the original image,the amount of blurring can be controlled by changing light source used for the initial unsharp mask exposure, while the strength of the effect can be controlled by changing the contrast and density (i.e., exposure and development) of the unsharp mask.The resulting image, although clearer, may be a less accurate representation of the image's subject. In the context of signal processing, an unsharp mask is generally a linear or nonlinear filter that amplifies the high-frequency components of a signal. Unsharp masking be used with a large radius and a small amount (such as 30–100 pixel radius and 5–20% amount) which yields increased local contrast,and it called as local contrast enhancement. USM can increase either sharpness or (local) contrast because these are both forms of increasing differences between values, increasing slope—sharpness referring to very small-scale (high-frequency) differences, and contrast referring to larger-scale (low-frequency) differences

FIG 4:Photographic Unsharp Masking

D. Nonlinear Spatial Filter

Non-linear filters have many applications, especially in the removal of certain types of noise that are not additive. For example, the median filter is widely used to remove spike noise that affects only a small percentage of the samples, possibly by very large amounts. Nonlinear spatial filters also operate on neighborhoods, and the mechanics of sliding a mask past an image are the same as was just outlined. The filtering operation is based conditionally on the values of the pixels in the neighborhood under consideration are inevitably slower than the median filter. Noise is smoothed locally, 'within' regions defined by object boundaries whereas little or no smoothing occurs between image objects. Nonlinear filters are considerably harder to use and design than linear ones, because the most powerful mathematical tools of signal analysis [11]

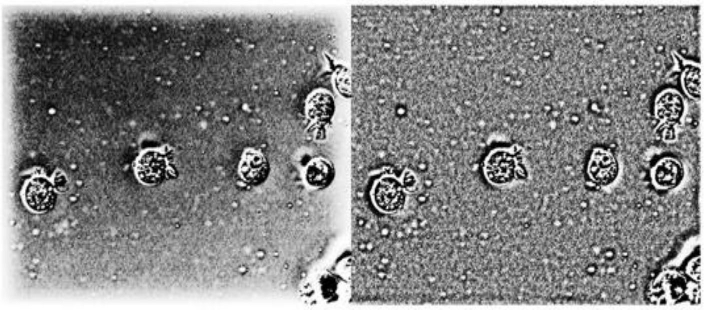

FIG 5: Nonlinear Spatial Filter

E. Weiner Filter

Wiener filter is based on a statistical approach, and a more statistical account of the theory is given in the MMSE estimator article. Typical filters are designed for a desired frequency response. The approach of reducing one degradation at a time allows us to develop a restoration algorithm for each type of degradation and simply combine them. The Wiener filtering executes an optimal tradeoff between inverse filtering and noise smoothing. It removes the additive noise and inverts the blurring simultaneously. Weiner filter gives the orinal as much it possible. The goal of the Wiener filter is to filter out noise that has corrupted a signal

FIG 5: Weiner Filter

Year	Author	Title	Approach	Result
2010	Iqbal, K.; Odetayo, M.; James, A.; Salam, R.A.; Talib, A.Z.H	"Enhancing the low quality images using Unsupervised Colour Correction Method"	Unsupervised Color Correction Method (UCM)	Increased Illuminatio and Contrast using UCM
2011	Jinbo Chen; Zhenbang Gong; Hengyu Li; Shaorong Xie	"A detection method based on sonar image for underwater pipeline tracker,".	Sonar image detection method	Reduces Implementation time
2012	Chiang, J.Y.; Ying-Ching Chen	"Underwater Image Enhancement by Wavelength Compensation and Dehazing,".	Wavelength Compensation and Dehazing	Improves the quality of the deep water images
2012	Sharif M. A. Bhuiyan, Jesmin F. Khan	Sharif M. A. Bhuiyan, Jesmin F. Khan	CBEMD	Better visual performance
2013	Hitam, M.S.; Yussof, W.N.J.H.W.; Awalludin,E.A.Bachok, Z.	Hitam, M.S.; Yussof, W.N.J.H.W.; Awalludin, E.A.; Bachok, Z	Adaptive Histogram Equalization by Enhancing contrast	Enhances the quality of the image

IV. Conclusion

This review paper covers the image enhancement techniques and the image quality enhancement using filers, the atmospheric light is a major difficulty to process underwater images comes from the poor visibility conditions under the water, scattering of light and light attenuation due to all the reasons the underwater images suffers a lot and affect their visibility and the contrast which they contain actually. In order to increase the efficiency of underwater images EMD provides better visual performance than conventional enhancement methods such as contrast stretching as well as alternative methods presented in the literature. The enhanced images provide more interpretability, visibility and are better in terms of color and clarity. The low contrast problem widely encountered in underwater images is relatively resolved with the proposed approach.Furthermore the contrast of images is improved.

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